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Optimizing the 3.5 GHz Band

September 4, 2013

BLiNQ Networks

- Backhaul Link with IQ (BLiNQ)
  - Founded in 2010 by a team of former Nortel engineers who acquired a portion of Nortel's IP and wireless assets
  - Created specifically to problem of connecting proliferating small cells back to the core network
  - Focused on point-to-multipoint non-line-of-sight (NLOS) Backhaul Solutions
- Approximately 40 employees
- Headquartered in Plano, Texas
- *FierceWireless* named BLiNQ one of its top 15 privately held wireless companies in 2012

NLOS Backhaul & the 3.5 GHz Band

- Small cells are one of the primary solutions to the spectrum crunch – but they require NLOS backhaul
  - NLOS backhaul is often the only potential method for connecting small cells to the core in urban and suburban areas
  - NLOS backhaul allows operators to deploy small cells exactly where they are needed rather than where fiber happens to be
- NLOS equipment can enable more efficient usage of the 3.5 GHz band while protecting incumbents
  - Equipment can support a Spectrum Access System (SAS) and can employ advanced interference mitigation strategies
- 3.5 GHz is one of the only remaining bands available that could enable NLOS backhaul
- Rules allowing for outdoor deployments coupled with priority access for users with objective quality of service (QoS) needs will promote optimal use of the band

Support for Key Elements of Approach

- The 3.5 GHz band should enable NLOS backhaul solutions to support robust heterogeneous networks
  - 4G Americas, PCIA, Qualcomm, Alcatel-Lucent, Ericsson, CCA, TIA, T-Mobile, Verizon, Microsoft, IEEE, WiMax Forum, Tarana Wireless, and Cambium Networks
- Priority Access based on QoS requirements provides a workable system encouraging efficient usage
  - AT&T, Verizon, Alcatel-Lucent, Google, and Nokia
- Technical rules should enable outdoor deployments
  - Google, PCIA, Rajant, TIA, Wireless Internet Service Providers Ass'n, and Utilities Telecom Council
- An SAS promotes efficient spectrum usage
  - Vanu, Qualcomm, PISC, Shared Spectrum Company, and Spectrum Bridge

Optimal Use of the Band

- The optimal sharing arrangement depends on the technologies and applications that will be used
  - Separate indoor and outdoor uses could allow for more efficient use of spectrum
  - Building attenuation can help manage co-channel and out-of-bound emission (OOBE) interference
- Co-existence in the band is highly dependent on the technical rules, including:
  - EIRP
  - Antenna Type/Pattern
  - Antenna Installation Height and Downtilt
  - OOBE Requirements
- Co-existence relying on power coordination, together with building attenuation, is possible with fair and precise rules for all users

Coordination relying solely on the compatibility of radio layer technology will be very difficult as many technologies may be deployed in the band and the mix of technologies will change over time

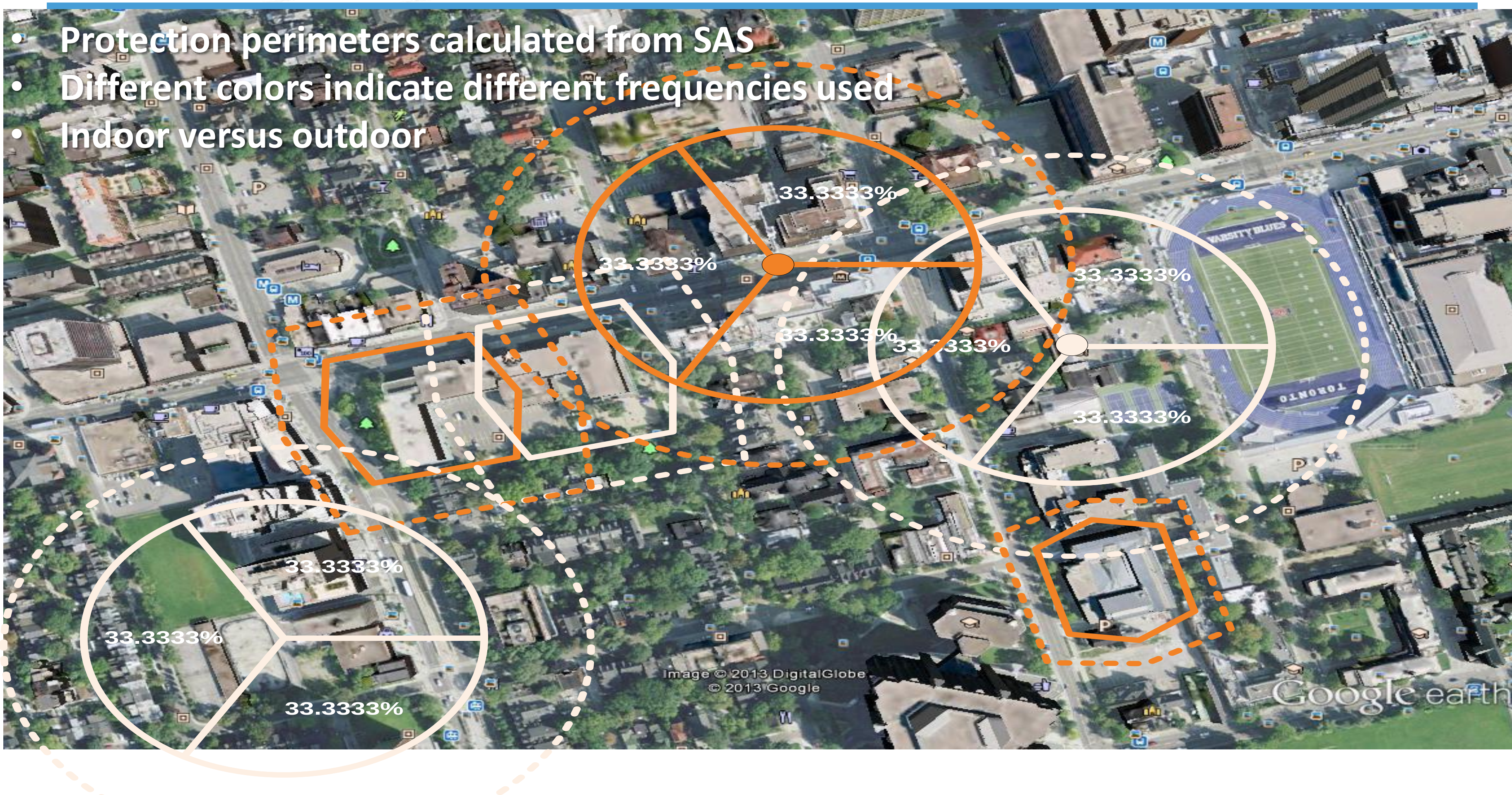
Potential Uses

- Femto Cells – Low Power Indoor Systems
  - According to Qualcomm, a power limit of “20mW/+13 dBm is sufficient”
  - An EIRP of +20 dBm would ensure coexistence of systems in separate buildings (and may even allow coexistence on different floors of the same building)
- Hot Zones – Medium Power Outdoor Systems (Pico Cells)
  - Power: ~250 mW/+24 dBm
  - EIRP: +40 dBm, coupled with tight antenna and downtilt requirements
- Non Line of Sight (NLOS) Backhaul – Medium Power Outdoor Systems
  - EIRP: +40 dBm
  - 400-500 m coverage in urban areas and ~ 1 km coverage in suburban/residential areas
- Rural Connectivity – High Power/Long Distance
  - Not efficient for purposes of sharing and spectrum reuse, but there is more spectrum available in rural areas

Band Sharing Approaches

- Time Sharing
  - Requires tight coordination, which is unlikely unless WiFi-type devices are deployed
    - WiFi approach does not allow for the QoS necessary to enable small cell deployments
  - Multiple technologies will use this band, so time coordination may prove difficult
  - Interoperator time division will prove more difficult still
- Frequency/Geography Sharing
  - Very workable, relying on reasonable in- and out- of band emissions limits
  - Geo-location coordination
  - Could rely on a “protection perimeter” for each system based on EIRP and OOBE, as well as deployment specifics (antenna height, downtilt, pattern)
  - Spectrum Access System should have capability to collect interference sensing information from deployed systems and mandate specific power control policy
  - Elements of self-optimizing networks (SON) can be employed to further improve performance

Frequency/Geography Sharing



- Coexistence based on coordinating protection perimeters

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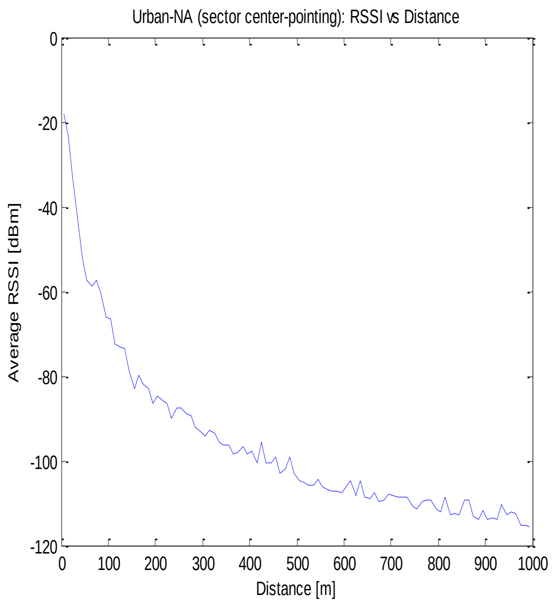
NLOS Backhaul Case Study

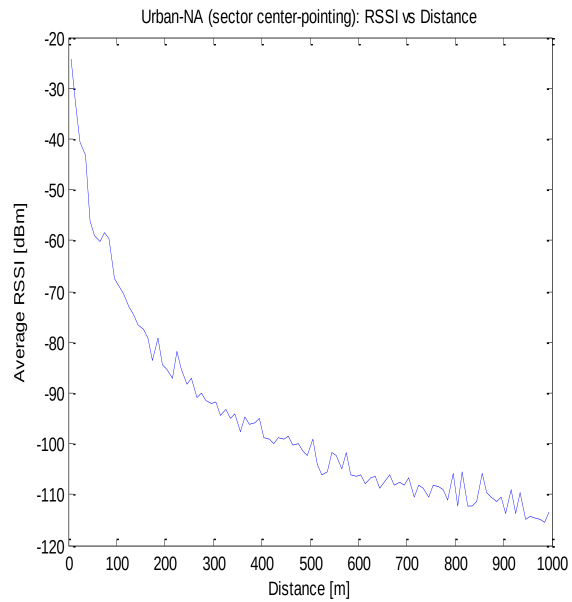
- EIRP limit of +40 dBm (3.65 GHz – 10 MHz channel)
- 3 Use Cases (NLOS, line of sight (LOS), Mixed LOS/NLOS)
  - In urban areas, 1 km LOS deployment would be very rare
  - To demonstrate a worst case scenario, however, our analysis assumed a 1 km unobstructed LOS corridor
- A very simple projection shows that with reasonable deployment specifications:
  - A 1 km or smaller protection perimeter can assure seamless coexistence of outdoor systems
  - Accounting for in-building isolation – a 500 meter protection perimeter could be sufficient to permit indoor/outdoor coexistence

Urban-North America Use Case (sector-center pointing): Average Received Signal Strength Indicator vs. Distance

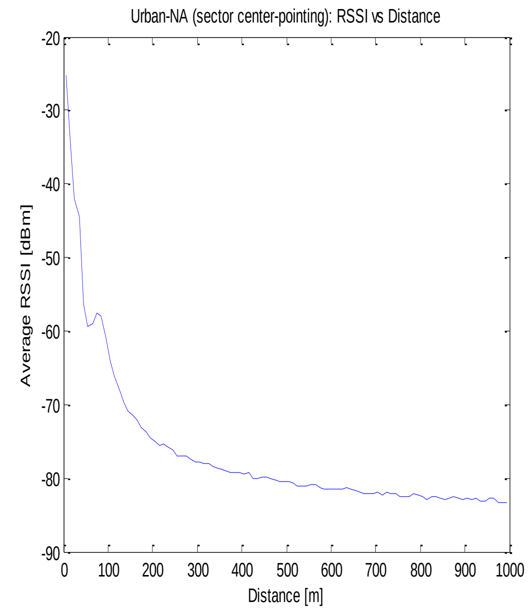
Pure NLOS



Mixed NLOS/LOS



Pure LOS



	HM height (m)	RBM height (m)	Building height (m)	Street width (m)	Radius (m)	Sector-edge pointing: downtilt deg	Sector-center pointing: downtilt deg
Urban-NA	30	5	20	30	400	3.6	7.1

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Frequency/Geography Sharing Proposal
Key Elements

A. Optimal Spectrum Usage
- Define Bands and Channel Structure
- Clarify Tier Structure
- Define OOBE (and/or installation) requirements and channel structure so no guard bands are required between channels

B. Frequency/Geography Sharing: Protection Zones & Coordination
- Optimal Perimeter Protection Zone
  - Trade-off between network performance and number of uses that can co-exist
- Frequency Coordination managed by SAS
  - Device Sensing Requirements
  - Logical interface between SAS and Device

C. Reduce Exclusion Zones
- Rules promoting optimal spectrum usage and frequency/geography sharing can reduce FSS Earth Station exclusion zones

Shortcomings of Present 3.65 GHz

- The FCC database requires additional data for carriers to make informed deployment decisions:
  - Details on antennas, including downtilt, elevation, and height
  - Frequency channel (center frequency and bandwidth) for each sector
  - OOBE
- Channel structure is very important for SONs
  - Scanning and sensing
  - Transitioning to alternate channels
- There are currently no rules other than the “quiet rule” when activity is detected
  - Definition of activity is inadequate (e.g., is it any activity above the noise floor?)
  - Requires further protocol when sudden activity is detected (i.e., an operation rule)
  - A “quiet rule” effectively prohibits backhaul and access uses for the spectrum
- Solution: SAS Database with reliable SON features

Optimal Spectrum Usage

- Channel Structure Proposal
  - Organize the entire band into 10 or 20 MHz channels
- Higher Power Uses in Limited Parts of the Band
  - Band could be split into parts (channel bundles), allowing for relaxed EIRP limits and thus higher power systems in a limited portion of the band
  - The FCC should minimize the proportion of the band with a relaxed EIRP because a relaxed EIRP reduces potential for coexistence
- Tier Structure
  - Priority Tier for NLOS backhaul will increase spectrum usage and functionality
  - Priority Tier for outdoor NLOS backhaul use can be coupled with Priority Tier for indoor access use
    - Priority Tier guarantees quality of service necessary for these uses
  - Could consider a single tier with possibility to apply for priority:
    - SAS (licensing entity) would define a larger perimeter protection zone that would guarantee safe functionality of priority devices

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Frequency/Geography Sharing

Indoor Priority
(Higher EIRP for indoor)
Outdoor - GAA
Rural/Backhaul - GAA

Outdoor Priority
(Higher EIRP for outdoor)
Indoor - GAA
Rural/Backhaul - GAA

Rural - Priority
(Higher EIRP for rural/backhaul)
Indoor - GAA
Outdoor - GAA

- The tiered model could prioritize certain types of operations over others in segments of the band to ensure each service model could always offer reasonable QoS in at least one segment of the band while maintaining access to the full band.
  - In Indoor Priority tier – indoor allowed a more relaxed EIRP and all other uses allowed on a GAA-basis
  - Outdoor and Rural/Backhaul Priority tiers could follow this same model

Spectral Emissions Mask & OOBE

- For adjacent channel coexistence, ETSI EN 302 544-1 (*Broadband Data Transmission Systems operating in 2500-2690 MHz band, TDD BS requirements*) provides a good model
  - "Close-in" emissions mask given for various channel bandwidths and transmit powers, from channel edge to 2x channel bandwidth offset from edge
  - Transmitter adjacent-channel leakage requirements (ACLR), adjacent and alternate-adjacent channels
  - Transmitter spurious emissions for offsets > 2.5x channel bandwidth offset from center, baseline requirements (-30 dBm/30 kHz at 2.5x extending to -30 dBm/MHz at 12x), and more stringent co-existence requirements (-45 dBm/MHz at 2.5x)
- The ECCREP131 Test Report (*Derivation of Block Edge Emissions Mask for TS*), as well as other reports, explain the considerations behind these standards.

Frequency/Geography Sharing

- Sharing discipline for systems within same tier
- Systems from lower tiers must scan and, if any activity is detected, cannot transmit
- Systems in each tier (band group) – would comply with emissions over a desired perimeter and extended perimeter computed based on:
  - EIRP information
  - Downtilt and Installation requirements
  - Assumption is that emissions outside each perimeter must be under a certain received signal level (RSL)
- Frequency/Geography Sharing information must be available in SAS
  - Each system must continuously sense and submit standard reports to SAS
- Based on such information operators would determine feasibility of deployment
- Systems would operate as follows:
  - Systems that are already deployed should not sense in-band interference over standard threshold (dependent on perimeter and EIRP rules)
  - Systems that deploy outside such protection perimeter should not sense in-band emissions over standard threshold
  - Otherwise interfered system must report rule violation to SAS, and SAS would activate mediation layer:
    - Validate complaint and check interference source
    - Require interferer to power down device
- Systems from same priority tier already deployed would grandfathered in relation to other priority systems based on perimeter protection zone
- Systems from lower priority tier are never grandfathered in a higher priority tier

Optimal Sharing Using SAS

- How can the spectrum be optimally shared using SAS?
  - License requester should submit detailed information on:
    - Geo-Location of base station
    - Antenna pattern, direction, height, and tilt
  - SAS (Licensor) will provide information on channel availability, neighboring uses, and anything else required for cell planning activity
  - SAS could compute <u>licensee protection and operation perimeter</u>, as well as potential interference. SAS could deliver installation and power recommendations to licensee.

SAS and Device Requirements

Device Requirements

- Support channel sensing (contention based protocol, at a minimum)
- Support SAS communication protocol
- Have the ability to comply with SAS requests
- Have the ability to communicate location, required bandwidth, QoS parameters, and channel-sensing information

SAS Requirements

- Provide adequate information to allow prospective users to assess feasibility of deployment
- Communicate over standard designated protocol to all operating devices
- Store and compile information related to operating devices
- Compute protection perimeter zone for operating devices
- Manage dynamic channel assignments
- When violation of noise floor is detected in a protection perimeter:
  - Identify interferer
  - Advise power adjustment or other corrective action

Exclusion Zones

- Current exclusion zones in the 3.65-3.7 GHz band can be significantly reduced
- Smaller exclusion zones are possible with small cells, allowing more efficient use of this spectrum
- Exclusion zones could be managed by SAS
- Exclusions zones should be focused only on protecting incumbents; low-power devices should be allowed to operate at their own risk (relying on, for example, filtering)

Questions?